1857MNRAS..17..136C

### *Parthenope.*

| Mean Solar Time of Observation. | | Apparent R.A. | Apparent N.P.D. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1857, Jan. 31 | 14 3 34·13 | 10 48 29·25 | 79 14 32·27 |
| Feb. 16 | 12 48 21·71 | 10 36 9·38 | 77 28 14·41 |
| 24 | 12 9 40·27 | 10 28 54·02 | 76 32 40·11 |
| 26 | 11 59 58·41 | 10 27 3·67 | 76 19 9·74 |
| 28 | 11 50 16·96 | 10 25 13·75 | 76 6 0·06 |

### *Lutetia.*

| Mean Solar Time of Observation. | | Apparent R.A. | Apparent N.P.D. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1857, Jan. 19 | 8 12(30) | ...... | 68 45 51·19 |
| Feb. 14 | 6 40 47·98 | 4 19 42·14 | 67 59 15·60 |

There is some doubt whether the above places are those of *Lutetia.*

### *Fides.*

| Mean Solar Time of Observation. | | Apparent R.A. | Apparent N.P.D. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1857, Jan. 27 | 14 46 21·55 | 11 15 37·48 | 82 16 40·23 |
| Feb. 16 | 13 14 15·20 | 11 2 7·12 | 81 3 2·06 |
| 24 | 12 35 38·04 | 10 54 56·05 | 80 26 37·02 |
| 26 | 12 25 54·71 | 10 53 4·23 | 80 17 24·28 |

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## *The Occultations of Jupiter and his Satellites on the 2d of January, as observed at the Cambridge Observatory.* By Professor Challis.

"I delayed sending to the Astronomical Society my observations of the occultation of *Jupiter*, till I could complete certain calculations founded upon them, which proved to be long and intricate. The results of the calculations are added to the following account of the observations.

"Expecting a good opportunity, I made every requisite preparation for observing the occultations with the Northumberland equatorial. My junior assistant, Mr. Taylor, counted from a chronometer, and recorded the times; so that, while observing

1857MNRAS..17..136C

the times of immersion and emersion, I was at liberty to notice physical phenomena. The magnifying power employed was 215. Mr. Breen observed, by himself, with the 5-feet equatorial, using a power of 120. The following are the Greenwich mean times of the occurrences, as deduced from the noted times of the two observers. The letters C and B indicate the observers.

*Greenwich Mean Times of Disappearances.*

| | C | | | B | |
|---|---|---|---|---|---|
| | h | m | s | s | |
| Satellite IV. | 4 | 45 | 31·46 | 31·60 | (*a*) |
| — III. | 4 | 53 | 2·47 | 3·47 | (*b*) |
| Jupiter, beginning | 4 | 59 | 47·98 | 50·35 | (*c*) |
| — end | 5 | 1 | 27·18 | 27·19 | (*d*) |
| Satellite I. | 5 | 2 | 16·48 | 16·85 | (*e*) |
| — II. | 5 | 3 | 29·05 | 27·98 | (*f*) |

*Greenwich Mean Times of Reappearances.*

| | C | | | B | |
|---|---|---|---|---|---|
| | h | m | s | s | |
| Satellite IV. | 5 | 38 | 32·54 | ... | (*g*) |
| — III. | 5 | 49 | 52·55[1] | 32·20 | (*h*) |
| Jupiter, beginning | 5 | 59 | 13·57 | 18·40 | (*i*) |
| — , end | 6 | 0 | 44·77 | 44·56 | (*k*) |
| Satellite I. | 6 | 1 | 57·07 | 71·91 | (*l*) |
| — II. | 6 | 3 | 40·57 | 58·33 | (*m*) |

" The following are the notes which I made in the observing-room immediately after the respective observations :—

" '(*a*) The satellite disappeared gradually: the time noted is the mean between the beginning and end of obscuration, which occupied about $1\frac{1}{2}^{s}$. (*b*) Gradually, as before. It first appeared cut off a second earlier: the time noted is that of bisection of the satellite by the moon's limb. (*c*) The time of first contact, perhaps, a little late: half a second after the recorded time the limb was quite perceptibly cut off. (*d*) This time is very exact. (*e*) Time of bisection: disappeared rather more suddenly than the two preceding. (*f*) Occupied in disappearing about the same time as satellite I.

" 'During the occultation of *Jupiter* I noticed particularly the form of his disk. I could not perceive any elongation of the line of section by the moon's limb, the contour of *Jupiter* appearing continually round. I lost the impression of his oblateness. The moon's limb was faintly visible. When *Jupiter* was about half cut off, I remarked that the section was rather jagged, and in particular that there was a bright projection at about the middle point.

" '(*g*) First seen at this time, when it was about $4''\cdot5$ from

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[1] An error of $20^{s}$ in recording.

1857MNRAS..17..136C

the limb. (*h*) First seen at 2″ from the limb. (*i*) Time rather late: the limb projected perhaps 2″·5. (*k*) This is exact. (*l*) 2″ from the limb. (*m*) Good: the satellite seen adhering to the limb.

" 'I thought *Jupiter*, at reappearance, seemed flattened towards the moon's limb. My attention was a good deal directed to a faintish shadow running along the moon's limb, and of about 4″ in breadth. This continued during the whole of the reappearance. Just at the total emergence the point of contact was obscure, and seemed to recede from the moon's limb. Perhaps the noted time of complete emergence may, on this account, be a little too early. The emergence took place at a depression of the moon's limb, extending beyond *Jupiter* on both sides. This was very conspicuous. The moon's irradiation appeared cut off at this part.'

" Mr. Breen noted as follows:—

" 'Times of disappearing beautifully exact. The satellites were about $1\frac{1}{2}^{s}$ in disappearing. Circumstances very favourable. No perceptible distortion in the form of *Jupiter:* its oblate shape very noticeable during the time of its disappearance.

" 'The observations of reappearance satisfactory, but those of the satellites not as good as the observations of disappearances. They appeared *instantaneously*. During the time of emersion *Jupiter* seemed indented into the moon's limb. No distortion of its shape was noticed.'

" To the foregoing rough notes I beg to add a few remarks. The atmospheric circumstances of the observations were particularly good; both *Jupiter* and the moon's limb appearing at times with extraordinary definition. This was remarkably the case at *Jupiter's* emergence, the moon's limb during the whole time and after being quite sharp and free from irradiation. The planet, when fairly separated, was strikingly beautiful: its contour and belts were steady and distinct: being visibly brighter at the central part of the disk than towards the border, it had something of a pellucid appearance: its light was pale compared to that of the moon, and had the slightest possible tinge of olive green. The most remarkable phenomenon was the dark fringe bordering the moon's limb: it was darker than *Jupiter's* belts; and continuing to the end of the emersion, made the observation of last contact somewhat difficult. This circumstance seems to prove that the fringe could not be the mere effect of contrast between the moon's light and that of *Jupiter*. Describing it after the observation, I said it reminded me of *Saturn's* dusky ring. The bright projection noticed at the immersion was due to an indent in the moon's limb, and its brightness was probably remarked in consequence of its being situated between the two principal belts. This observation seems to show that no such phenomenon as the dark fringe occurred at the immersion. Can this phenomenon be connected in any way with the circumstance that the emersion took place at a depressed part of the moon's limb? I made an attempt to measure

1857MNRAS..17..136C

the depth of the depression when the moon was of the same age in the next lunation, and obtained, with some uncertainty, 1″·8, the state of the atmosphere not being favourable. I have no reason to conclude that the form of *Jupiter* suffered distortion either at immersion or emersion, the flattened appearance which I noticed at emersion being probably only the oblateness.

" The estimations of the distances of the objects from the moon's limb when first seen on reappearance, were made by means of the known interval between the teeth of the micrometer-comb. This method of estimation was subsequently verified by first estimating and then reading off intervals between the micrometer wires. The emersion of the 4th satellite was seen late from my not being prepared for it, and not knowing exactly where to look. I can hardly account for not seeing the 3d and 1st satellites and *Jupiter's* 1st limb earlier, as they were looked for in the right places. They seemed to come into view suddenly. Mr. Breen's times of emersion of the 1st and 2d satellites were proved by calculation to be much too late.

### *Calculation, from the foregoing Observations, of the Positions of the Satellites relative to Jupiter's Centre.*

"Let $p$ be the difference of apparent R.A., estimated on the arc of a great circle, and $q$ the difference of apparent N.P.D. of *Jupiter's* centre, or a satellite, and the moon's centre, at the noted time of immersion, and $p + \alpha$, $q + \beta$, the same for that of emersion. Then, S being the moon's apparent semidiameter at the first time, and $S + \varepsilon$ the apparent semidiameter at the second time, inclusive of estimated distance from the moon's limb, we shall have very nearly—

$$p^2 + q^2 = S^2 \text{ and } (p + \alpha)^2 + (q + \beta)^2 = (S + \varepsilon)^2.$$

"Consequently if $\frac{q}{p} = \tan \phi$ and $\frac{\beta}{\alpha} = \tan \theta$, the following equations determine $\phi$, $p$ and $q$:

$$\cos (\phi - \theta) = - \frac{\alpha}{2\, S \cos \theta} + \frac{\varepsilon \cos \theta}{\alpha} \left(1 + \frac{\varepsilon}{2\, S}\right)$$

$$p = S \cos \phi, \qquad q = S \sin \phi.$$

" To effect the calculations by these formulæ, the differences of the apparent R.A. and N.P.D. of the moon and *Jupiter*, and the moon's apparent semidiameter, at $4^h$, $5^h$, $6^h$, and $7^h$, were first calculated from the tables: whence $\alpha$, $\beta$, and S, were inferred by interpolation to second or third differences. The calculations having been gone through for the times of immersion and emersion of *Jupiter's* centre, the resulting values of $p$ and $q$ showed that the tabular excess of the moon's apparent R.A. above that of *Jupiter* required the correction − 5″·48, and the tabular excess of apparent N.P.D. the correction + 7″·30.

" To find $\alpha$ and $\beta$ for a satellite, it was necessary to take account

1857MNRAS..17..136C

of the satellite's motion in R.A. and N.P.D. between the immersion and emersion. This was done by means of the data for calculating the co-ordinates $x$ and $y$ relative to *Jupiter*, which are given for each satellite in the Berlin Ephemeris. The direction of the axis of $x$ was first assumed approximately, and the error of the assumption then corrected by the result of the calculation. The differences of the R.A. and N.P.D. of the moon and satellite were then deduced from the above formulæ for the time of immersion, and the corrected differences of R.A. and N.P.D. of the moon and *Jupiter* for the same time being known, those of *Jupiter* and the satellite were immediately inferred. The following are the principal results of the calculations:—

| Greenwich M.T. | Satellite. | Jupiter — Satellite, R.A. | N.P.D. | Distance from Jupiter by Observation. | Tabular Distance. | Excess of Observation. |
|---|---|---|---|---|---|---|
| h m s | | ″ | ″ | ″ | ″ | ″ |
| 5 2 16·7 | I. | + 57·07 | − 20·59 | 60·67 | 57·00 | + 3·67 |
| 5 3 28·5 | II. | + 94·29 | − 36·61 | 101·08 | 92·22 | + 8·86 |
| 4 53 2·5 | III. | −220·04 | + 111·04 | 246·47 | 240·94 | + 5·53 |
| 4 45 31·5 | IV. | −458·35 | + 221·02 | 508·86 | 502·55 | + 6·31 |

"These results depend on the assumed values of the semidiameters of the moon and *Jupiter*, which were taken without alteration from the *Nautical Almanac*. *Jupiter's* equatorial diameter, as inferred from the interval occupied by the immersion, the form of the disk being taken into account, is found to be 19″·14, which probably should be increased by a small fraction of a second, it being scarcely possible by this kind of observation to obtain the full amount of the diameter. The value inferred from the duration of the emersion, and corrected by + 1″·25 for the estimated distance of *Jupiter's* first limb from the moon, is 18″·43. The assumed tabular value is 19″·59. It would thus appear that the assumed semidiameter is at least not too small, and consequently that the above excesses of observation indicate that the ratios of the mean distances of the satellites to *Jupiter's* equatorial semidiameter, as given in the Berlin Ephemeris, require some correction. No attempt has been made to take into account the effect of the depression of the moon's limb at the place of emergence."

Mr. R. C. May, of No. 4 Sloane Terrace, also witnessed the dark shadow on the disk of *Jupiter*, seen by so many other observers. He forwarded a very well-executed drawing, almost identical with those of Mr. Lassell and the Messrs. Simms, in our previously published accounts. The telescope used by Mr. May was a Newtonian of 6 feet focus, and 6·9 inches aperture, made by himself. The magnifying power employed was not stated.